

Amendments to the Claims

The following listing of claims will replace all prior versions and/or listings of claims in the application:

Listing of Claims:

1-946. (cancelled)

947. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

heating a portion of the formation to a temperature sufficient to support oxidation of hydrocarbons in the heated portion, wherein the heated portion is located in the formation substantially adjacent to a wellbore;

providing an oxidant to a conduit positioned in the wellbore;

allowing the oxidant to flow from the conduit to a heat source zone in the heated portion, wherein the heat source zone supports an oxidation reaction between the oxidant and hydrocarbons in the heat source zone;

allowing at least a portion of the oxidant to react with hydrocarbons in the heat source zone to generate heat;

removing excess oxidant from the heat source zone to inhibit the oxidant from flowing to ~~the~~a pyrolysis zone in the formation; and

allowing heat to transfer substantially by conduction to ~~a~~the pyrolysis zone in the formation to pyrolyze at least a portion of ~~the~~ hydrocarbons in the pyrolysis zone.

948. (previously presented): The method of claim 947, wherein heating the portion of the formation comprises raising a temperature of the heated portion above about 400 °C.

949. (previously presented): The method of claim 947, wherein the conduit comprises critical flow orifices, the method further comprising allowing the oxidant to flow through the critical

flow orifices to the heat source zone.

950. (previously presented): The method of claim 947, further comprising removing oxidation reaction products from the heat source zone through the wellbore.

951. (cancelled)

952. (previously presented): The method of claim 947, further comprising allowing the oxidant to transport through the heat source zone substantially by diffusion.

953. (previously presented): The method of claim 947, further comprising heating the conduit with heat from oxidation reaction products being removed through the wellbore.

954. (original): The method of claim 947, wherein the oxidant comprises hydrogen peroxide.

955. (original): The method of claim 947, wherein the oxidant comprises air.

956. (original): The method of claim 947, wherein the oxidant comprises a fluid substantially free of nitrogen.

957. (previously presented): The method of claim 947, further comprising limiting an amount of oxidant provided to the conduit to maintain a temperature of the heat source zone below about 1200 °C.

958. (previously presented): The method of claim 947, further comprising electrically heating the portion of the formation to the temperature sufficient to support oxidation of hydrocarbons.

959. (previously presented): The method of claim 947, further comprising using exhaust gases from a surface burner to heat the heated portion of the formation to the temperature sufficient to support oxidation of hydrocarbons.

960. (previously presented): The method of claim 947, further comprising using a flameless distributed combustor to heat the heated portion of the formation to the temperature sufficient to support oxidation of hydrocarbons.

961. (previously presented): The method of claim 947, further comprising controlling a pressure and a temperature in at least a majority of the pyrolysis zone, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

962. (previously presented): The method of claim 947, further comprising controlling an amount of oxidant provided to the conduit to control heating of the pyrolysis zone such that an average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis.

963. (previously presented): The method of claim 947, wherein heating of the pyrolysis zone increases a thermal conductivity of at least a portion of the pyrolysis zone to greater than about 0.5 W/(m °C).

964. (previously presented): The method of claim 947, further comprising controlling a pressure in at least a majority of the pyrolysis zone of the formation, wherein the controlled pressure is at least about 2.0 bars absolute.

965. (previously presented): The method of claim 947, further comprising:
providing hydrogen (H₂) to the pyrolysis zone to hydrogenate hydrocarbons in the pyrolysis zone; and
heating a portion of the pyrolysis zone with heat from hydrogenation.

966. (previously presented): The method of claim 947, wherein heating of the pyrolysis zone increases a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

967. (previously presented): The method of claim 947, wherein heating of the pyrolysis zone

increases a permeability of a majority of the pyrolysis zone such that the permeability of the majority of the pyrolysis zone is substantially uniform.

968. (previously presented): The method of claim 947, wherein heating of the pyrolysis zone is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

969. (previously presented): The method of claim 947, wherein the wellbore is located along strike of the formation to reduce pressure differentials along a heated length of the wellbore.

970. (previously presented): The method of claim 947, wherein the wellbore is located along strike of the formation to increase uniformity of heating along a heated length of the wellbore.

971. (previously presented): The method of claim 947, wherein the wellbore is located along strike of the formation to increase control of heating along a heated length of the wellbore.

972. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

heating a portion of the formation to a temperature sufficient to support oxidation of hydrocarbons in the portion of the formation;

providing an oxidant to a conduit, wherein the conduit is positioned such that the oxidant flows from the conduit to the heated portion;

allowing the oxidant to oxidize at least some hydrocarbons in a heat source zone to produce heat in the heat source zone;

allowing heat to transfer from the heat source zone to a pyrolysis zone in the formation to pyrolyze at least a portion of the hydrocarbons in the pyrolysis zone;

controlling an amount of oxidant provided to the conduit to control heating of the pyrolysis zone such that an average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis; and

removing oxidation products from the heat source zone such that the oxidation products

are inhibited from flowing from the heat source zone to the pyrolysis zone.

973. (previously presented): The method of claim 972, wherein heating the portion of the formation comprises raising the temperature of the heated portion above about 400 °C.

974. (previously presented): The method of claim 972, further comprising electrically heating the portion of the formation to the temperature sufficient to support oxidation of hydrocarbons.

975. (previously presented): The method of claim 972, further comprising using exhaust gases from a surface burner to heat the heated portion to the temperature sufficient to support oxidation of hydrocarbons.

976. (previously presented): The method of claim 972, wherein the conduit comprises critical flow orifices, the method further comprising allowing the oxidant to flow through the critical flow orifices to the heated portion.

977. (previously presented): The method of claim 972, wherein the conduit is located in a wellbore, and wherein removing oxidation products comprises removing oxidation products from the heat source zone through the wellbore.

978. (previously presented): The method of claim 972, further comprising removing excess oxidant from the heat source zone to inhibit the oxidant from flowing to the pyrolysis zone.

979. (previously presented): The method of claim 972, further comprising allowing the oxidant to transport through the heat source zone substantially by diffusion.

980. (previously presented): The method of claim 972, wherein the conduit is located in a wellbore, the method further comprising heating the conduit with heat from oxidation products being removed through the wellbore to raise a temperature of the oxidant passing through the conduit.

981. (original): The method of claim 972, wherein the oxidant comprises hydrogen peroxide.

982. (original): The method of claim 972, wherein the oxidant comprises air.

983. (original): The method of claim 972, wherein the oxidant comprises a fluid substantially free of nitrogen.

984. (previously presented): The method of claim 972, further comprising limiting an amount of oxidant provided to the conduit to maintain a temperature of the heat source zone below about 1200 °C.

985. (previously presented): The method of claim 972, further comprising limiting an amount of oxidant provided to the conduit to maintain a temperature of the heat source zone at a temperature that inhibits production of oxides of nitrogen.

986. (previously presented): The method of claim 972, further comprising using a flameless distributed combustor to heat the heated portion to the temperature sufficient to support oxidation of hydrocarbons.

987. (previously presented): The method of claim 972, further comprising controlling a pressure and a temperature in at least a majority of the pyrolysis zone of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

988. (cancelled)

989. (previously presented): The method of claim 972, wherein allowing the heat to transfer from the heat source zone to the pyrolysis zone comprises allowing the heat to transfer substantially by conduction.

990. (previously presented): The method of claim 972, wherein heating of the pyrolysis zone increases a thermal conductivity of at least a portion of the pyrolysis zone to greater than about 0.5 W/(m °C).

991. (previously presented): The method of claim 972, further comprising controlling a pressure in at least a majority of the pyrolysis zone, wherein the controlled pressure is at least about 2.0 bars absolute.

992. (previously presented): The method of claim 972, further comprising:
providing hydrogen (H₂) to the pyrolysis zone to hydrogenate hydrocarbons in the pyrolysis zone; and
heating a portion of the pyrolysis zone with heat from hydrogenation.

993. (previously presented): The method of claim 972, wherein heating of the pyrolysis zone increases a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

994. (previously presented): The method of claim 972, wherein heating of the pyrolysis zone increases a permeability of a majority of the pyrolysis zone such that the permeability of the majority of the pyrolysis zone is substantially uniform.

995. (original): The method of claim 972, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

996. (previously presented): An in situ method for heating a hydrocarbon containing formation, comprising:
heating a portion of the formation to a temperature sufficient to support oxidation of hydrocarbons in the portion of the formation, wherein the portion is located substantially adjacent to an opening in the formation;

providing an oxidizing fluid to a heat source zone in the heated portion, wherein the oxidizing fluid is provided at a rate sufficient to limit radial expansion of the heat source zone at a rate of less than 1.5 meters per year;

allowing the oxidizing fluid to react with at least a portion of the hydrocarbons in the heat source zone to generate heat in the heat source zone; and

allowing heat to transfer substantially by conduction from the heat source zone to a pyrolysis zone in the formation, wherein the heat source zone abuts the pyrolysis zone.

997. (previously presented): The method of claim 996, further comprising allowing the oxidizing fluid to transport through the heat source zone substantially by diffusion.

998. (original): The method of claim 996, further comprising directing at least a portion of the oxidizing fluid into the opening through orifices of a conduit disposed in the opening.

999. (previously presented): The method of claim 996, further comprising directing a flow of the oxidizing fluid through critical flow orifices on a conduit disposed in the opening, wherein the critical flow orifices control the flow of oxidizing fluid such that a rate of oxidation is controlled.

1000. (previously presented): The method of claim 996, further comprising removing an oxidation product from the formation through a conduit disposed in the opening.

1001. (previously presented): The method of claim 996, further comprising removing an oxidation product from the formation through a conduit disposed in the opening, and allowing the transfer of substantial heat between the oxidation product in the conduit and the oxidizing fluid.

1002. (previously presented): The method of claim 996, further comprising removing an oxidation product from the formation through a conduit disposed in the opening, wherein a flow

rate of the oxidizing fluid is approximately equal to a flow rate of the oxidation product in the conduit.

1003. (previously presented): The method of claim 996, further comprising removing an oxidation product from the formation through a conduit disposed in the opening, and controlling a pressure between the oxidizing fluid and the oxidation product in the conduit to reduce contamination of the oxidation product by the oxidizing fluid.

1004. (previously presented): The method of claim 996, further comprising providing the oxidizing fluid into the opening through a center conduit disposed in an outer conduit, and removing an oxidation product through the outer conduit.

1005. (original): The method of claim 996, wherein the heat source zone extends radially from the opening a width of less than approximately 0.15 m.

1006. (previously presented): The method of claim 996, further comprising heating the portion by applying electrical current to an electric heater disposed in the opening.

1007. (original): The method of claim 996, wherein the pyrolysis zone is substantially adjacent to the heat source zone.

1008. (previously presented): The method of claim 996, further comprising controlling a pressure and a temperature in at least a majority of the pyrolysis zone of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1009. (previously presented): The method of claim 996, further comprising controlling an amount of oxidizing fluid provided to the heat source zone to control heating of the pyrolysis zone such that an average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis.

1010. (previously presented): The method of claim 996, further comprising allowing heat to transfer through the pyrolysis zone substantially by conduction.

1011. (previously presented): The method of claim 996, wherein heating of the pyrolysis zone increases a thermal conductivity of at least a portion of the pyrolysis zone to greater than about 0.5 W/(m °C).

1012. (previously presented): The method of claim 996, further comprising controlling a pressure in at least a majority of the pyrolysis zone, wherein the controlled pressure is at least about 2.0 bars absolute.

1013. (previously presented): The method of claim 996, further comprising:
providing hydrogen (H₂) to the pyrolysis zone to hydrogenate hydrocarbons in the pyrolysis zone; and
heating a portion of the pyrolysis zone with heat from hydrogenation.

1014. (previously presented): The method of claim 996, wherein heating of the pyrolysis zone increases a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

1015. (previously presented): The method of claim 996, wherein heating of the pyrolysis zone increases a permeability of a majority of the pyrolysis zone such that the permeability of the majority of the pyrolysis zone is substantially uniform.

1016. (original): The method of claim 996, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1017-5395. (cancelled)

5396. (previously presented): The method of claim 947, further comprising producing a

mixture from the formation, wherein the mixture comprises hydrogen (H₂), and hydrogenating hydrocarbons with at least a portion of the H₂ from the mixture.

5397. (previously presented): The method of claim 972, further comprising producing a mixture from the formation, wherein the mixture comprises hydrogen (H₂), and hydrogenating hydrocarbons with at least a portion of the H₂ from the mixture.